Fluidization and water production in Chaos on Mars.

Fluidization and water production in Chaos on Mars. G. G. Ori[1] and C. Mosangini[2]. [1]Dipartimento di Scienze, Universita' d'Annunzio, Viale Pindaro 42, 65127 Pescara Italy, ggori@sci.unich.it, [2]DLR, Rudower Chaussee 5, 12489 Berlin Germany.

The catastrophic nature of the hydrodynamic processes occurring in the outflow channels is clearly demonstrated [1, 2]. This type of flood implies that the supply of water in the source areas should have a discharge rate comparable to that of the floods. Most source areas are chaos that show evidence of large scale deformation, that could be due to the production of water from a large subsurface reservoir. The deformed features of the chaos do not tell us about the rate of discharge from the subsurface aquifers. However, a sort of fluidization of the detritus - water system should occur in order to free the water from the pores. It is known that unconsolidated sediments on Earth, mostly when water-satured, have a capability of changing from solid-like to fluid-like and vice versa. The fluidization is usually triggered by some liquefaction of the detritus - water system in turn triggered by stressing events. Once the aquifer system is liquefied, the water along with the detritus start to flow by means of fluidization processes.

In the case of Martian subsurface ice, its melting can provide the triggering event to lead to liquefaction and fluidization of the system: i) the underground ice is melted either by endogenic or exogenic processes, ii) the transformation of the water from the solid to the liquid phase leaves an excess of pore volume, iii) the solid - liquid system collapse due to the empty pores, iv) the reduction of pore volume produces an increase of the pore fluid pressure, and, as a consequence, liquefaction. This sequence of events accounts also for the catastrophic release of water at the surface due to the slow rate of melting of subsurface ice. As a matter of fact, the collapse of the system will occur when the melting reachs a threshold; after that the collapse will occur dramatically inducing the formation of large catastrophic floods. A minimum fluidization velocity can be calculated according to the Carman-Kozeny equation [3]

$$V_f = 0.00114 \frac{(\quad - \quad)gD}{}$$

in which and are the densities of the solids and the fluid, is the fluid dynamic viscosity, g is the acceleration due to gravity, D the particle diameter (assumed spherical). This equation determine the passage from simple seepage to real fluidization (Fig 1) and indicates that on Mars the fluidization is easier due to the low value of g. Once fluidized, the passage to the hydraulic transport depends on the falling velocities of the solid particles (W)

$$W = \frac{8}{3} \frac{a(\quad - \quad)g}{C}$$

where C stands for a non-dimensional drag coefficient, to be either calculated theoretically or determined empirically.

The sequence of events occurring after the collapse of the solid - liquid subsurface systems is facilitated respect to the Earth by the lower gravity on Mars. The seepage stage is probably absent or rather instantaneous, while the fluidization stage will occur not only during the deformation and production of free water, but also during the early phase of the transport. Fluidization is of paramount importance in the formation of the chaos and of the outflow channels and provide some quantitative constrains on the interpretation of the production of water. Moreover, the threshold effect explains how triggering events with low rates of development can produce instantaneous liquefaction - fluidization and catastrophic floods. In general term, these changes of state occur when the upward-acting fluid drag exerted on the detritus exactly balances its downward-acting immersed weight. Beacuse the immersed weight on Mars is smaller, the states will change easier than on Earth. Moreover, the velocity required for fluidization is very small compared to the terminal fall velocity of solitary detritus in the unbounded fluid. Thus, large upward discharges are not necessary to fluidize detritus - liquid systems on Mars, but this process requires an open system with a continous supply of water. Beacuse fluidization is

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replaced by settling once the water supply terminates, the fluidization in the chaos and in the proximal outflow channels become hydraulic transport, controlled by the values of W.

The catastrophic events can also be due to a more complicated sequence of events. Some chaos (e.g. the Hydroates Chaos [4]) show evidence of the presence of lacustrine environments. In this case may be the fluidized water, instead of flowing directly into the outflow channels, filled lake basins corresponding to the chaotic terrains. Then the water could have been realised from the lakes to the channels.

The liquefaction - fluidization model is based on a relatively high mobility of the water in a solid - liquid system suggested by the low value of gravity. This fact will influence several hydrodanamic behaviours on Mars. Liquefaction will be matched by the formation of sedimentary (mud or sand) volcanoes that, once again, are facilitated by the low Martian gravity. These kind of features are not exensively recognised on the Martian surface, but this can be due to the lack of high resolution images. Sedimentary volcanoes are subtle features that can be confused with small volcanoes, cinder cone or knobs.

Another consequence of the influence of the gravity on W is the rate of transport that a Martian flood can support.because the lower falling velocities of the particles suggest that the floods can sustain for longer reaches the detritus. This fact has some consequences not only in the formation of the channels, but also in the formation of the deltaic environments that can be rather extensive and formed by a very flat sheet of sediments.
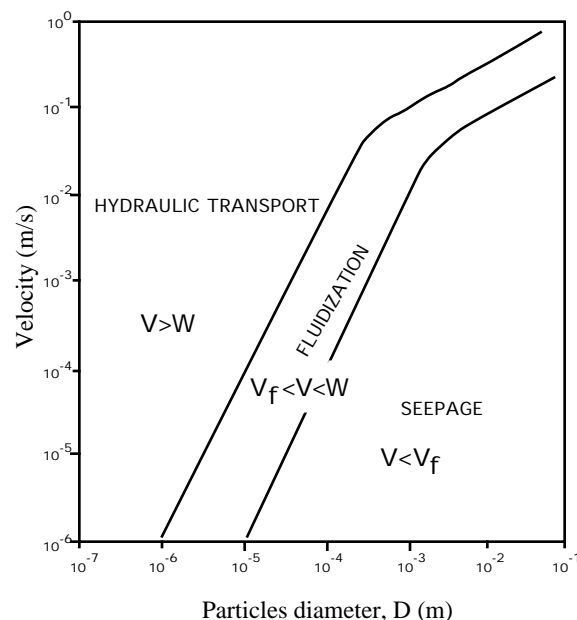

Figure 1.Changes of state during the formation of chaos and outflow channels (modified from [3])

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